Armed Forces College of Medicine

AFCM

Oxygen Transport And Oxyhemoglobin Dissociation Curve

Dr. Mohamed Fekry
Lecturer of Medical Physiology
AFCM

INTENDED LEARNING OBJECTIVES (ILOs)

By the end of this lecture the student will be able to:

1. Describe how the oxygen is transported in the blood.
2. Define Oxygen content, oxygen % saturation & oxygen partial pressure.
3. Describe with illustration the Oxy-Hb dissociation curve.
4. Explain significance of Oxy-Hb dissociation curve.
5. Define P50.
6. List and describe the factors that affect the position of Oxy-HB dissociation curve.
7. Describe the significance of 2,3 DBG in O_2 transport.
8. Explain the effects of fetal Hb & CO poisoning on HB affinity to oxygen.
9. Describe the myoglobin dissociation curve.

O_2 Transport

O_2 is transported in blood in two forms:-

1- In physical solution: (2%)

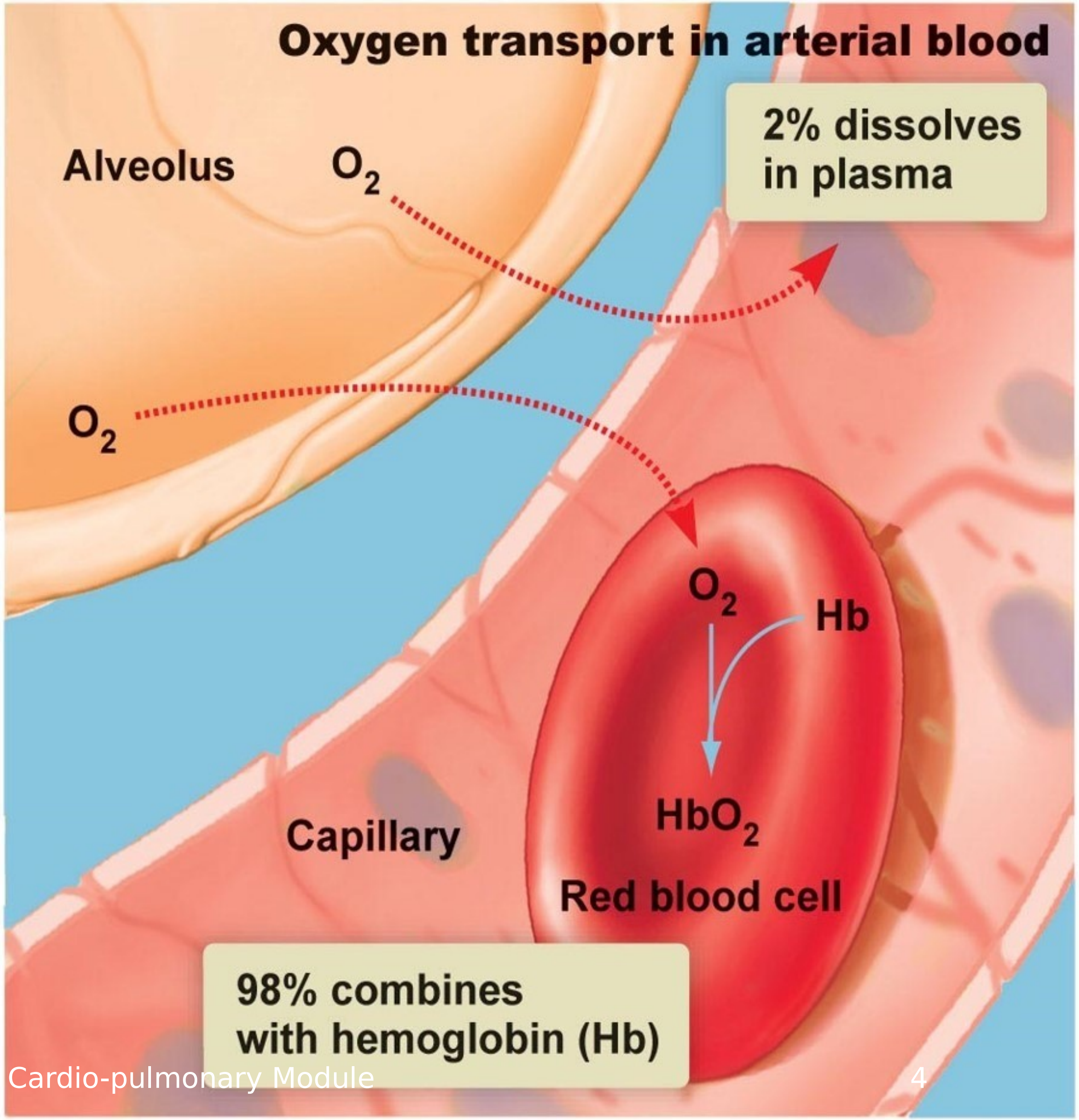
-It is dissolved in plasma

-It depends on blood **PO$_2$.**

(PO$_2$ **100** mmHg → 0.3 ml of O_2 is dissolved in 100 ml blood.)

2- In chemical combination with Hb: (98 %)

O_2 bind **reversibly** with the **ferrous ion** in Hb, so the reaction is called oxygenation

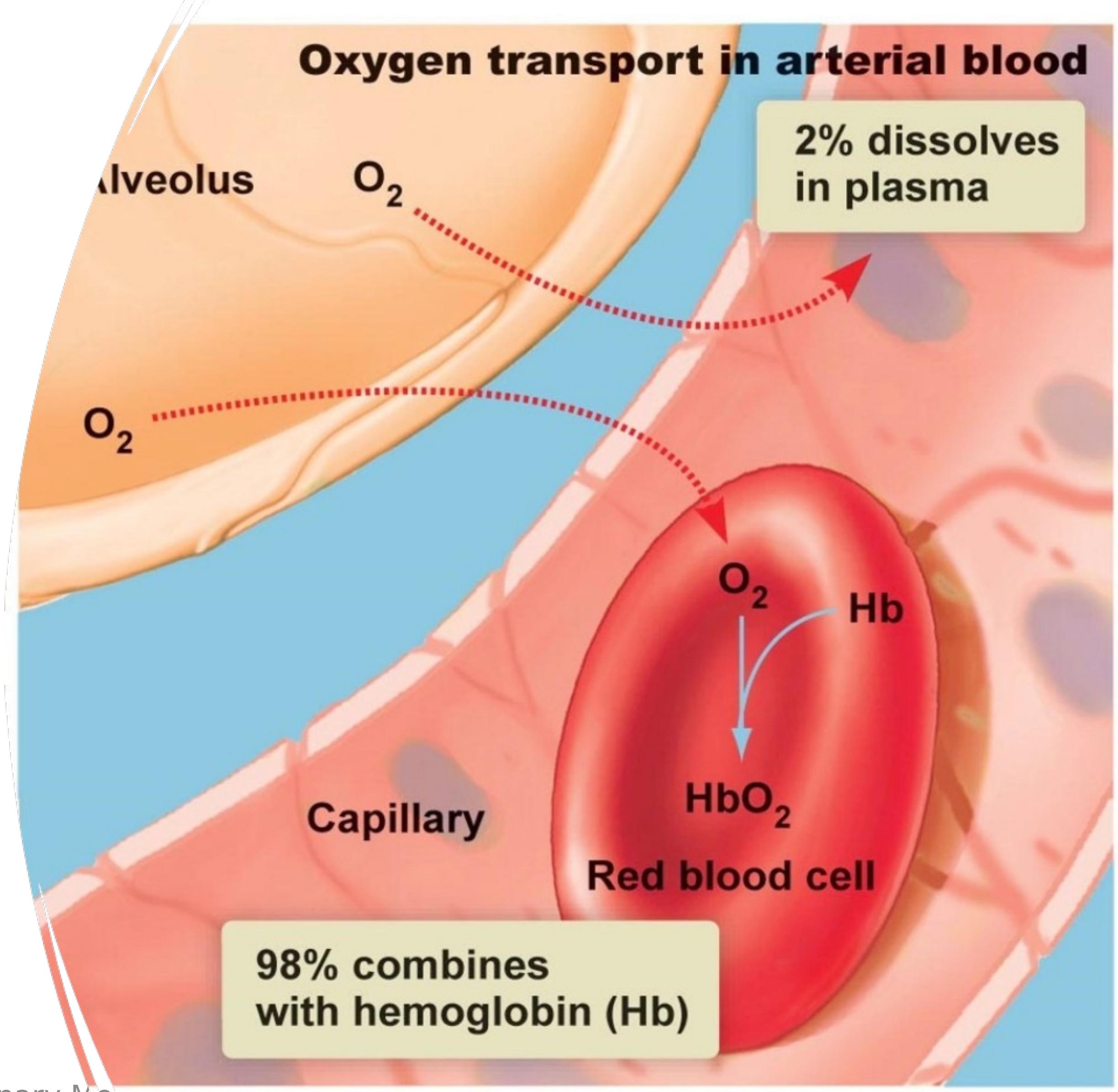


O_2 Transport

O_2 content of the blood :

It is the amount of O_2 which is in chemical combination with Hb in 100 cc of arterial blood.

= **19.5** ml/100 ml.



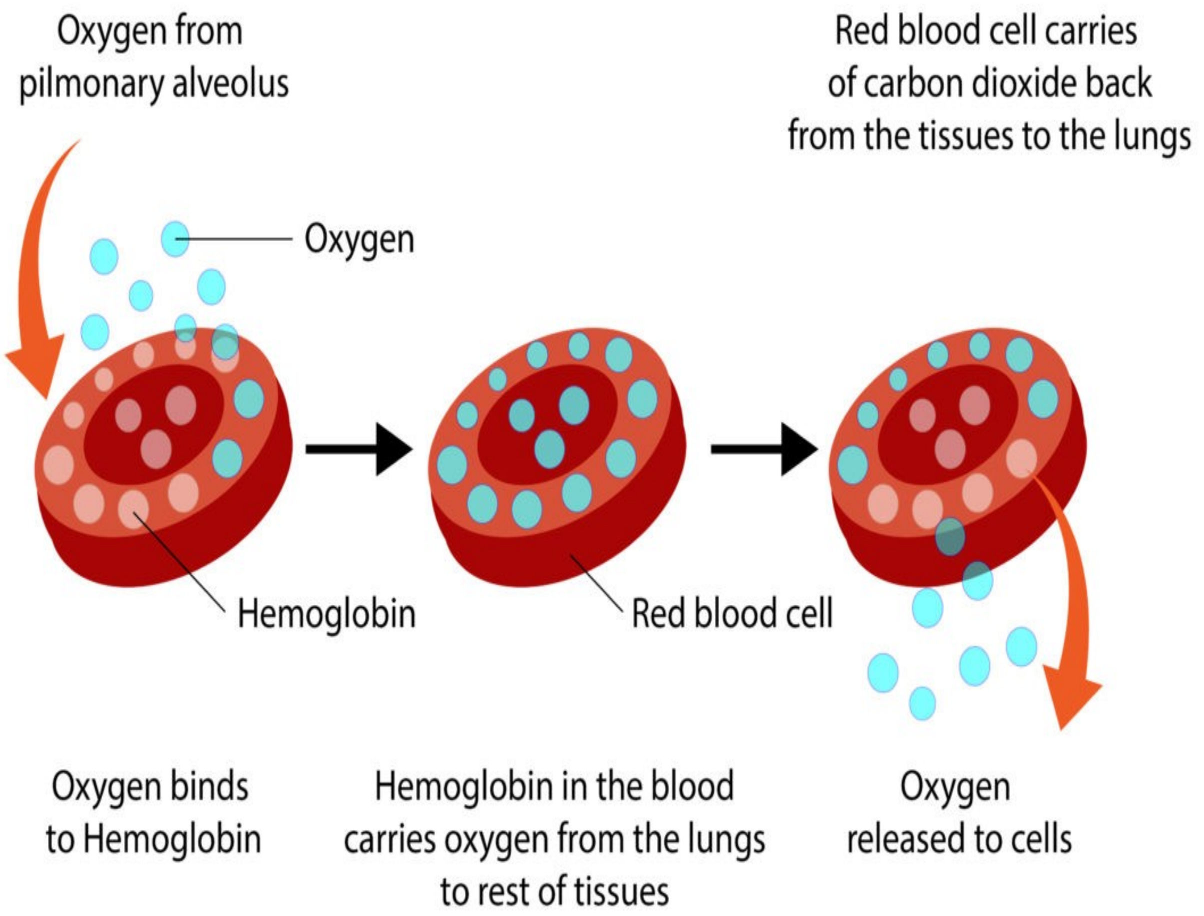
O_2 Transport

O_2 carrying capacity of the blood:
It is the maximal amount of oxygen which can be carried by Hb when it is fully saturated.

Each **1 gm** Hb can carry **1.34** ml O_2 (when it is fully saturated)

= Hb content **X** O_2 / 1 gm Hb

= 15 **X** 1.34



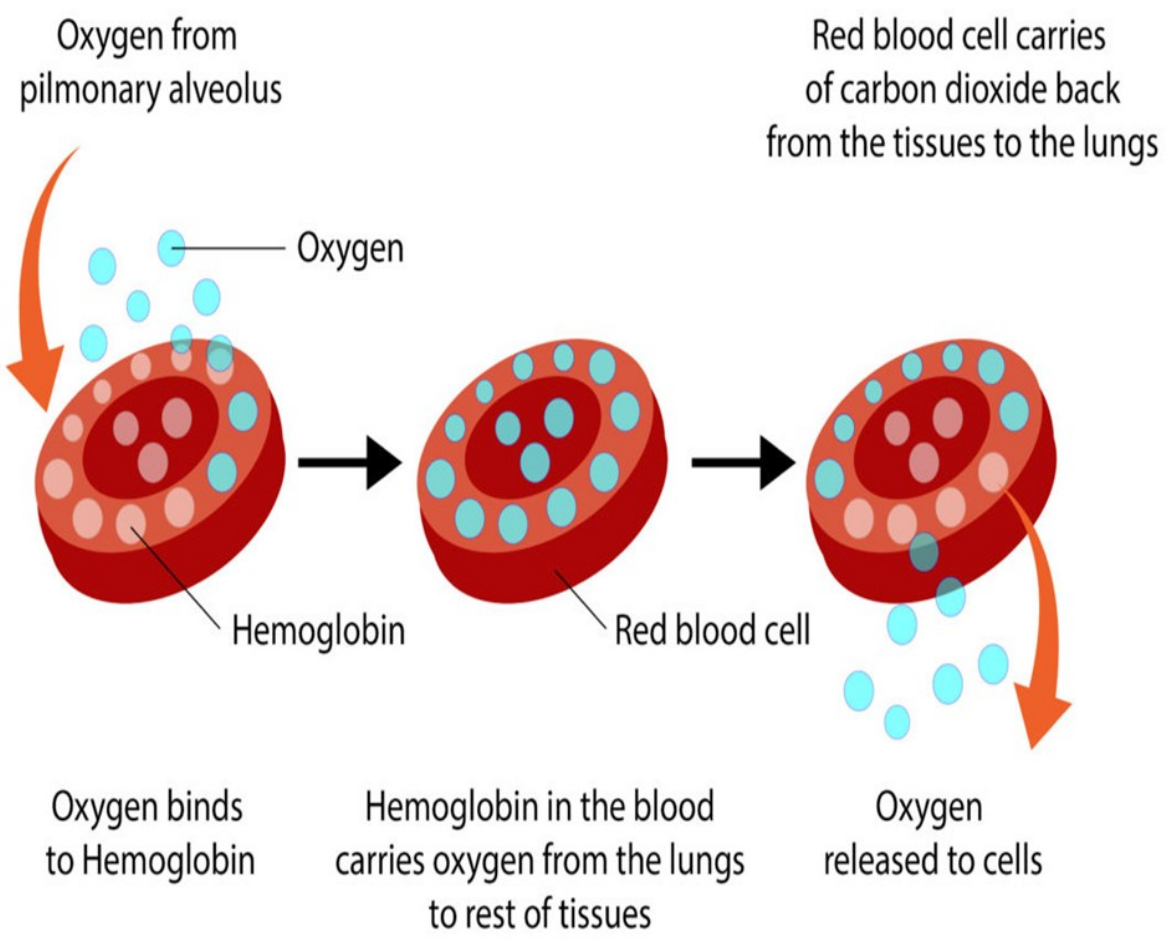
O_2% saturation:

$$= \frac{O_2 \textbf{ content}}{O_2 \textbf{ capacity}} \times 100$$

$$= \frac{\mathbf{19.5}}{\mathbf{20.1}} \times 100$$

= 97%

It is determined by **PO$_2$** which is related to the concentration of



Coefficient of oxygen utilization:

$$= \frac{\textbf{Oxygen utilized by tissues}}{\textbf{arterial } O_2 \textbf{ content}} \times 100$$

$$= \frac{\textbf{arterial } O_2 \textbf{ content} - \textbf{venous } O_2 \textbf{ content}}{\textbf{arterial } O_2 \textbf{ content}} \times 100$$

$$= \frac{\mathbf{19.5 - 14.5}}{\mathbf{19.5}} \times 100 = $$ **25 %** during <u>rest</u> (**75 %** during <u>exercise)</u>.

O_2 TRANSPORT

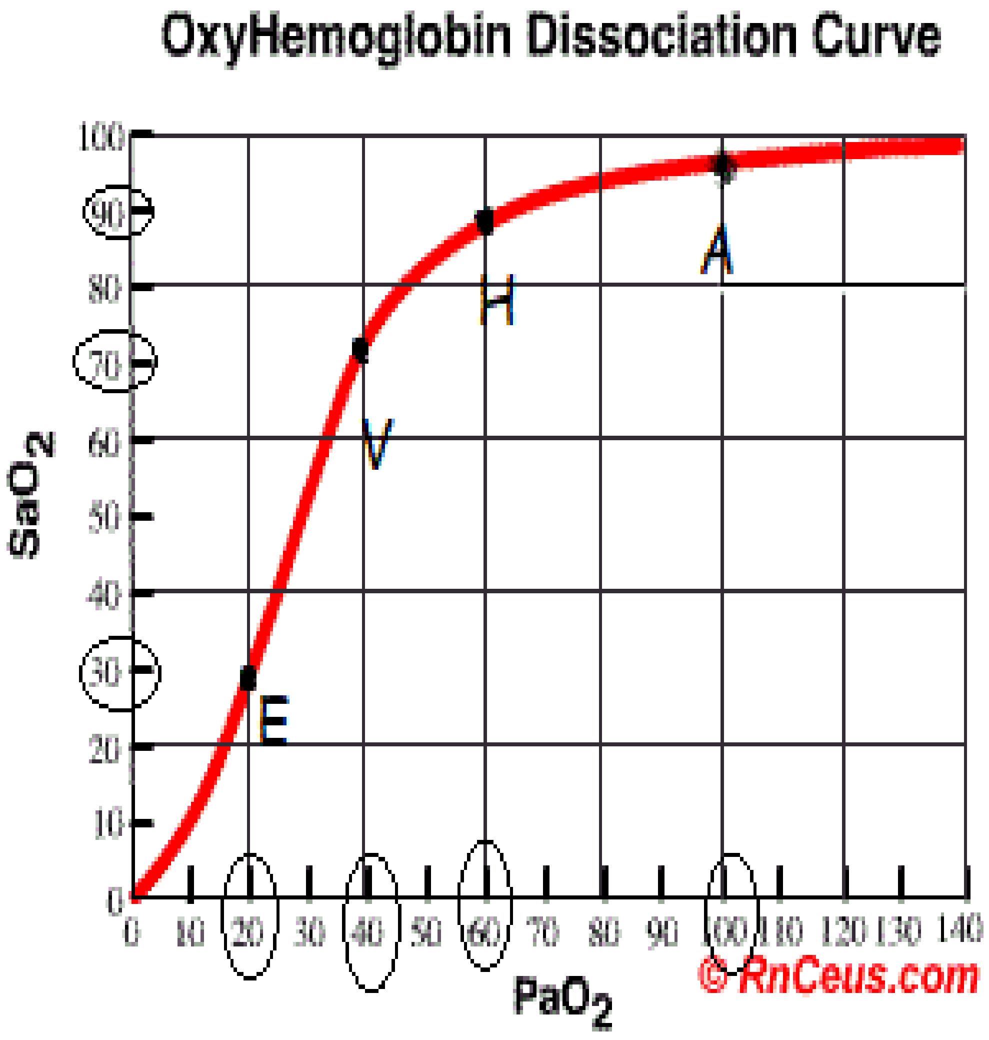
Oxygen partial pressure (PO_2):

-The pressure exerted by O_2 when it's present in a gas mixture.

-Partial pressure = the total pressure (P) X the fractional concentration of O_2 (PF)

Oxy-Hb Dissociation Curve

It is a curve that shows the relationship between **O2 tension** (PO2) & **% saturation of hemoglobin**.



The curve is S shaped as:

A = In **arterial blood**
(PO_2 =100 mmHg ,O_2 saturation =97%).

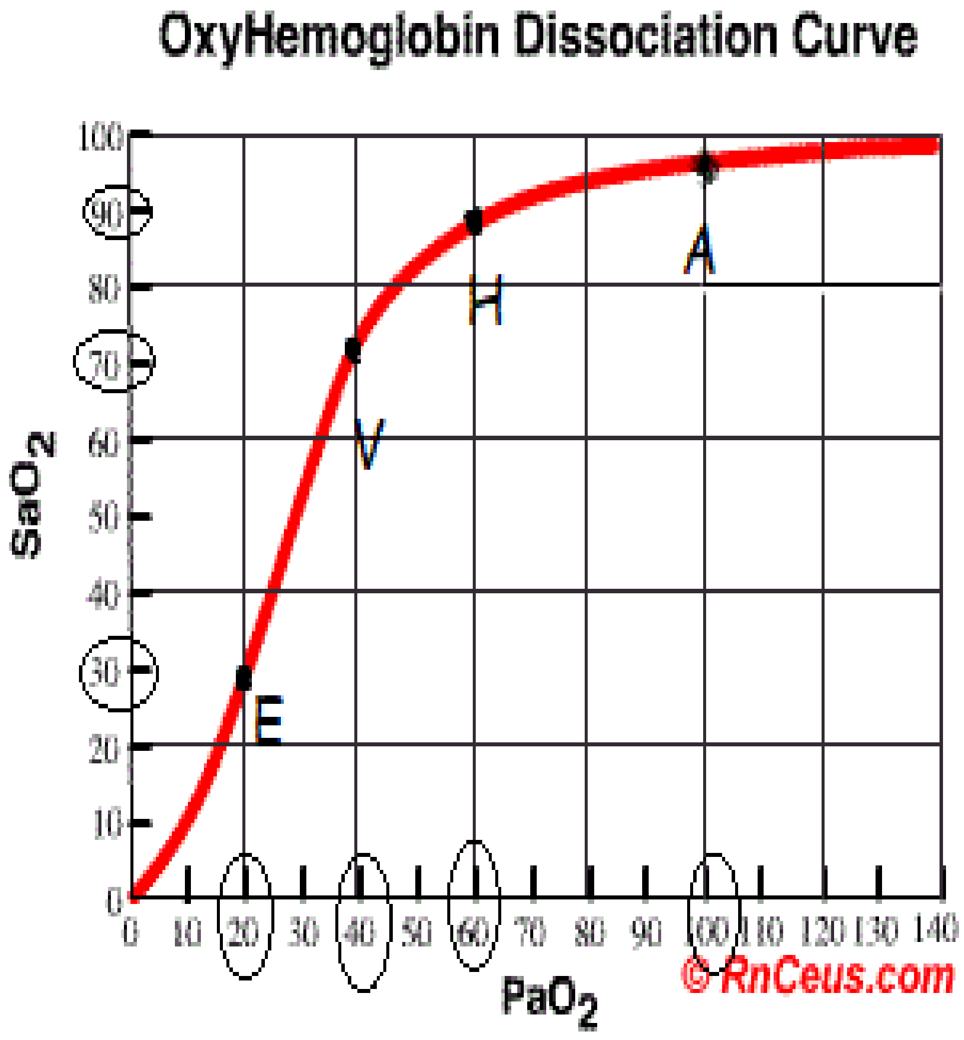
H= In **high altitude**
PO_2 decreased down to **60** mmHg, but % saturation decreased only to

Oxy-Hb Dissociation Curve

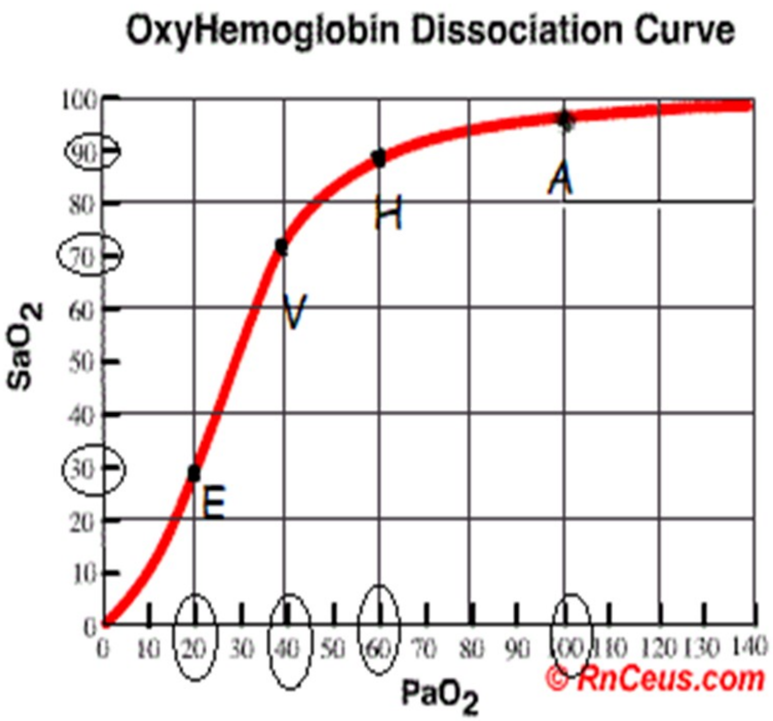
V = In **venous blood**
(PO_2 = **40**, O_2 saturation =**75%**)

Thus, O_2 dissociation during rest **=25%.**

E = In **muscular exercise**
(PO_2 = **20**, O2 saturation = **25%**).
Thus, oxygen dissociation during exercise **= 75 %.**



Oxy-Hb Dissociation Curve



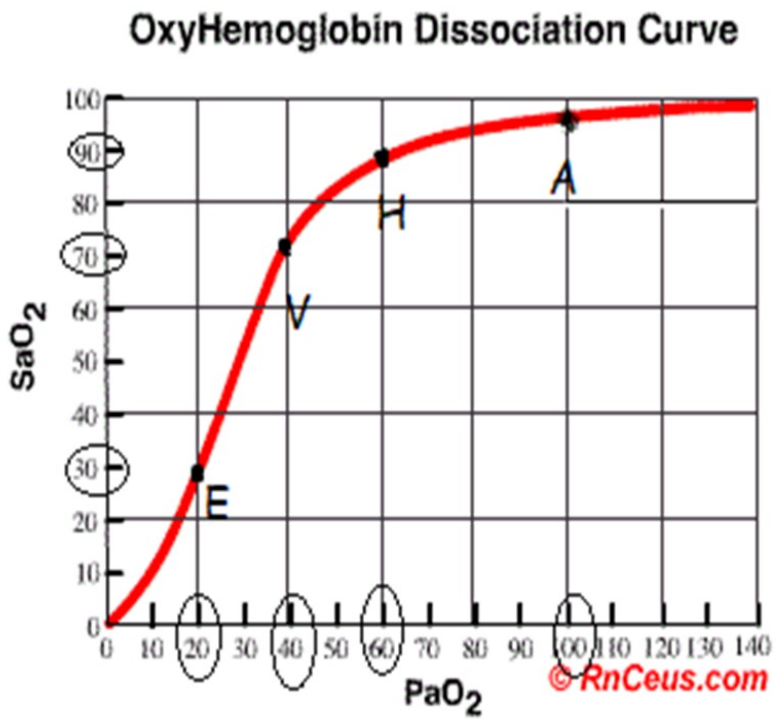
Significance of the **upper flat part** of the curve:

If arterial PO_2 falls from **100** to **60** mmHg, Hb saturation decrease only from **97%** to **90%.**

So, considerable reduction in O_2 tension below the normal arterial value does **not** significantly reduce the oxygenation of arterial blood.

This ensures the ability to survive at **high altitude** or in pathological conditions as pulmonary diseases characterized by defect in ventilation, perfusion and gas exchange.

Oxy-Hb Dissociation Curve



<u>Significance of the **steep upper part** of the curve</u>:

- It lies in blood PO_2 range from **60** to **40** mmHg (e.g. at tissue levels), a small drop in PO_2 causes marked drop in Hb saturation. So, large amount of O_2 is released to tissue.

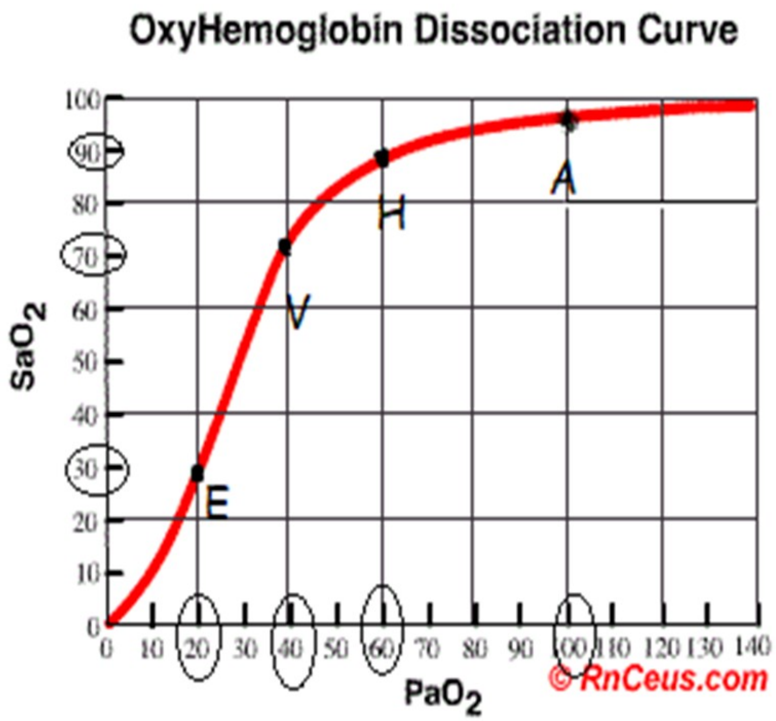
- At Venous blood (PO_2 = **40**, O_2 saturation =**75%**). Thus O_2 dissociation

Oxy-Hb Dissociation Curve

<u>Significance of the **steep lower part** of the curve</u>:

At PO_2 **below 40** mm Hg as in **muscular exercise**, Hb saturation decreased <u>markedly</u> thus releasing more O_2 to tissue.

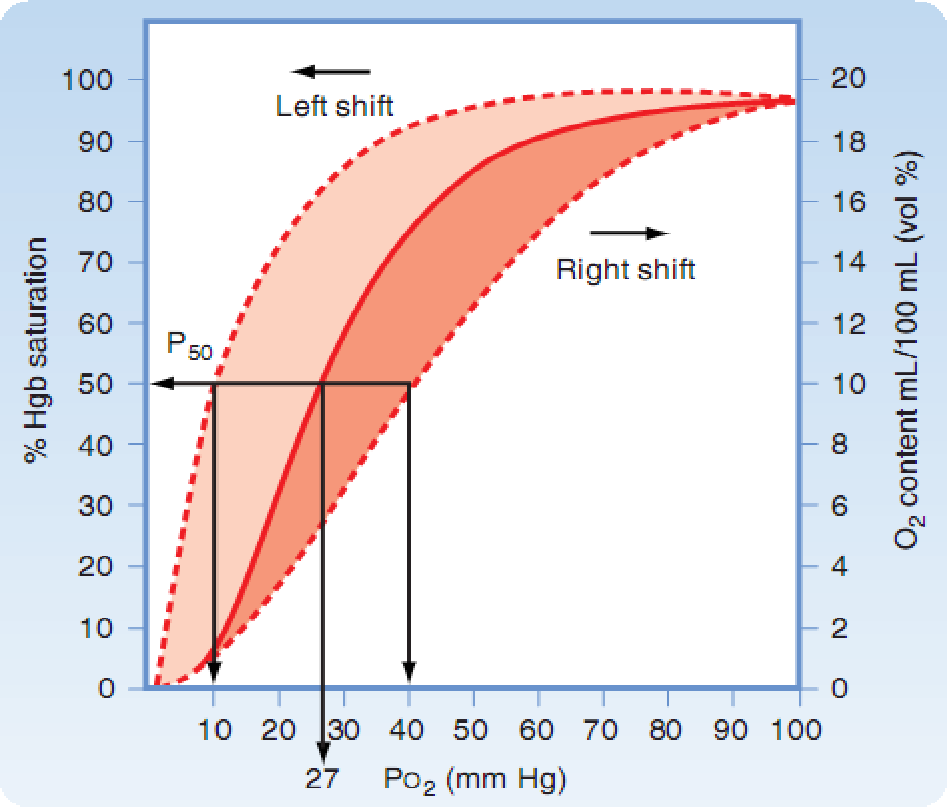
The **steep portion** is important at **tissue level** as in this range, small



Oxy-Hb Dissociation Curve

P_{50}:

- It is the value of PO_2 at which the blood is 50% saturated with O_2.
- Normally, **P_{50} = 26-28** mmHg.
- P_{50} is an inverse function of Hb affinity for O_2
- ↑ P_{50} =the curve is shifted to the **right**



Berne & Levy Physiology, 2018

Oxy-Hb Dissociation Curve

Shift to the Right:

↓ the affinity of Hb to O_2 → ↑ O_2 delivery to tissues.

causes:

1-Fever.

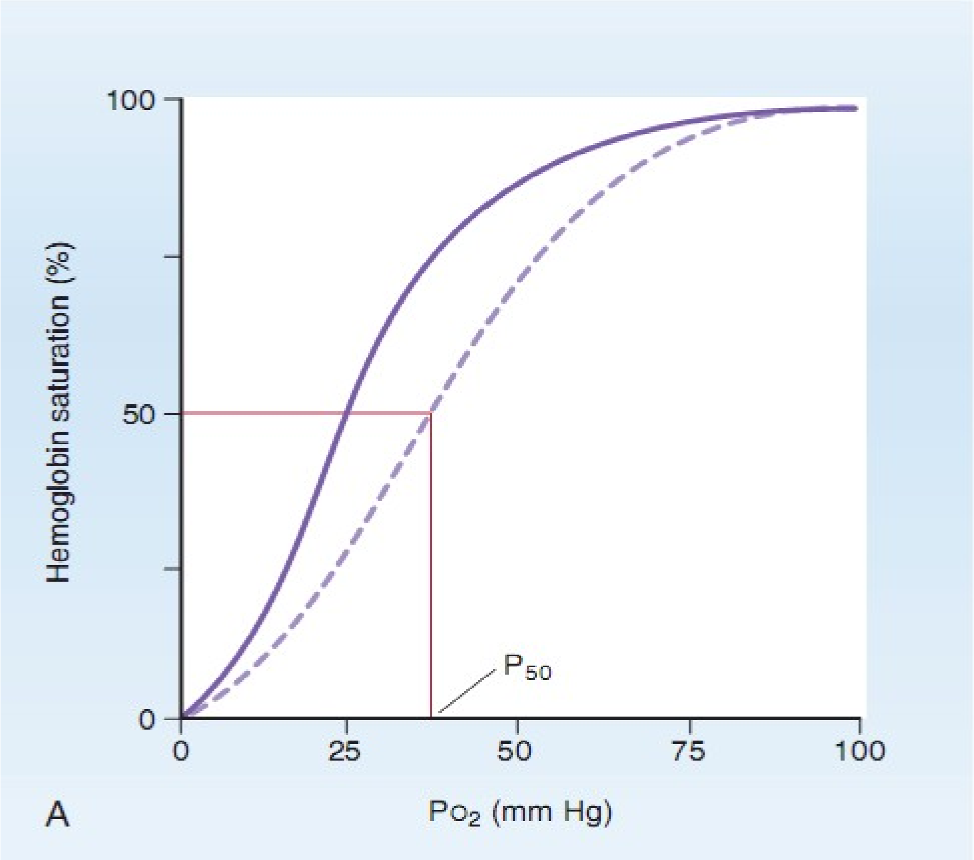
2-Acidosis.

3-Increase CO_2.

4-Increase 2,3 DPG.

5-Muscular exercise.

6-Maternal Hb.

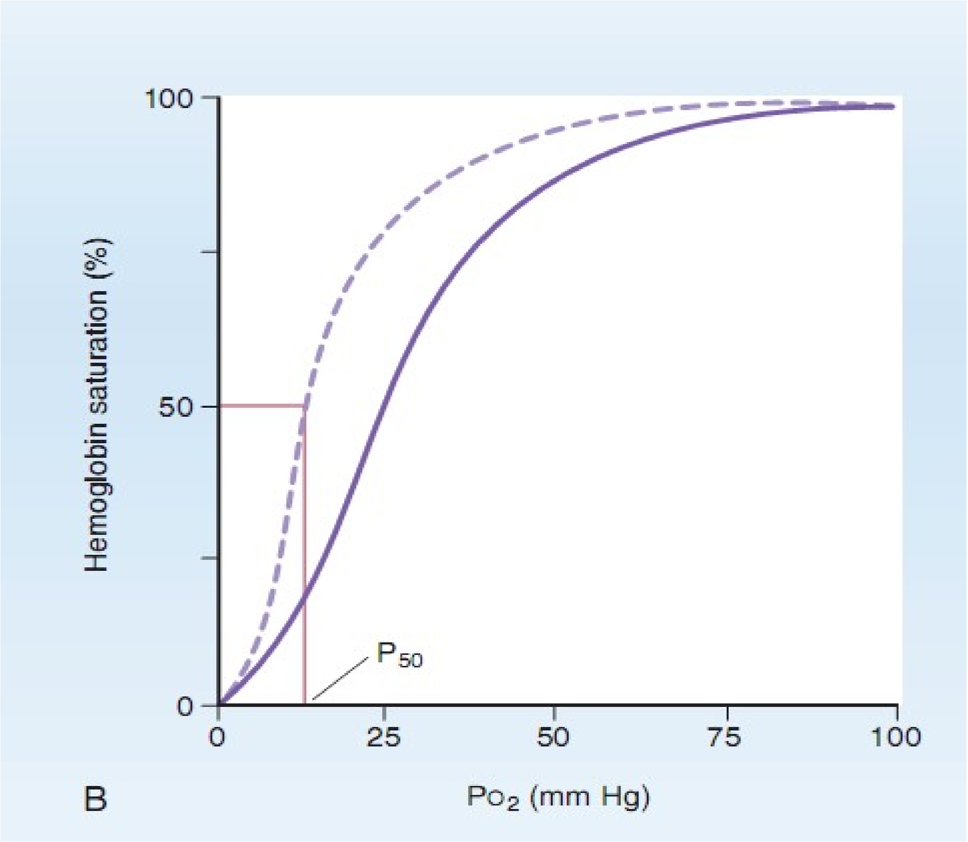


LINDA S. COSTANZO, 2018

Oxy-Hb Dissociation Curve

Shift to the Left:

↑ the affinity of Hb to O_2 → ↓ O_2 delivery to tissues.



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Causes:

1-Hypothermia.
2-Alkalosis.
3-Decrease CO_2.
4-Decrease 2,3 DPG.
5-Foetal Hb (no β chain).
6-CarboxyHb(CO).
7-MetHb (oxidation)

Oxy-Hb Dissociation Curve

2,3 diphsphoglycerate (2,3 DPG):

- Is formed by anaerobic glycolysis inside RBCs.
- It bind reversibly to **β** chain of adult Hb, decreasing its affinity to O_2 and causes shift of O_2 Hb curve to the **right.**
- It is **increased** in: muscular exercise, hyperthyroidism and chronic hypoxia.
- It is **decreased** in: deep sleep, stored blood ,acidosis and CO poisoning.

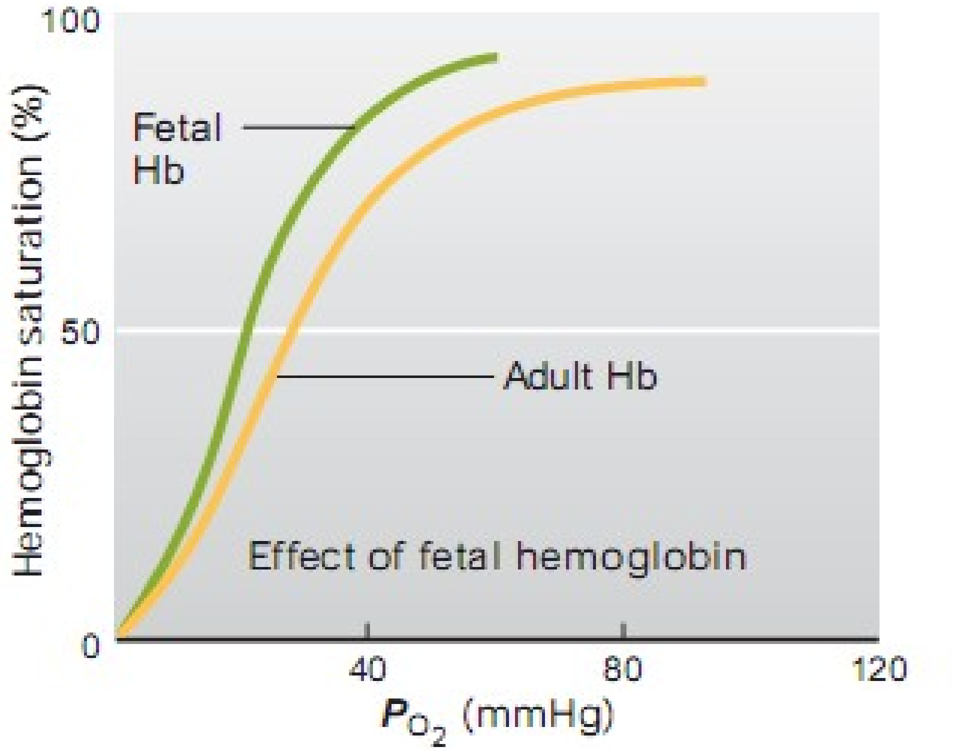
Oxy-Hb Dissociation Curve

Fetal blood:

Has high affinity for O_2, facilitating O_2 transport from mother to fetus.

Fetal blood contains less O_2 and less CO_2 than the maternal blood.

HbF has 2 γ chains (no β



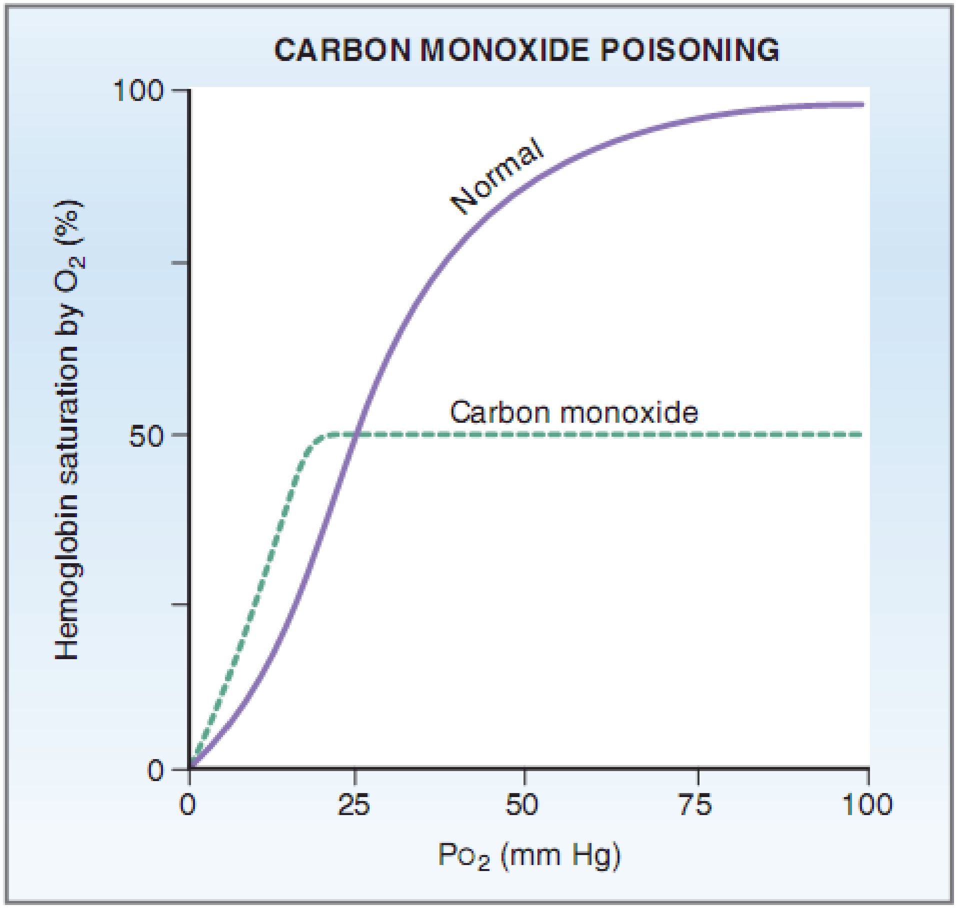
VANDER'S HUMAN PHYSIOLOGY, 2016

Oxy-Hb Dissociation Curve

CO poisoning:

- CO binds to Hb at the same site as O_2 and forms carboxyhemoglobin (HbCO).

- The affinity of Hb to CO is higher than O_2 + CO enhances the affinity of Hb for O_2 → dissociation curve to shift to the left → ↓ in both O_2-binding capacity of Hb and O_2 release to tissues → massive ↓ in O_2



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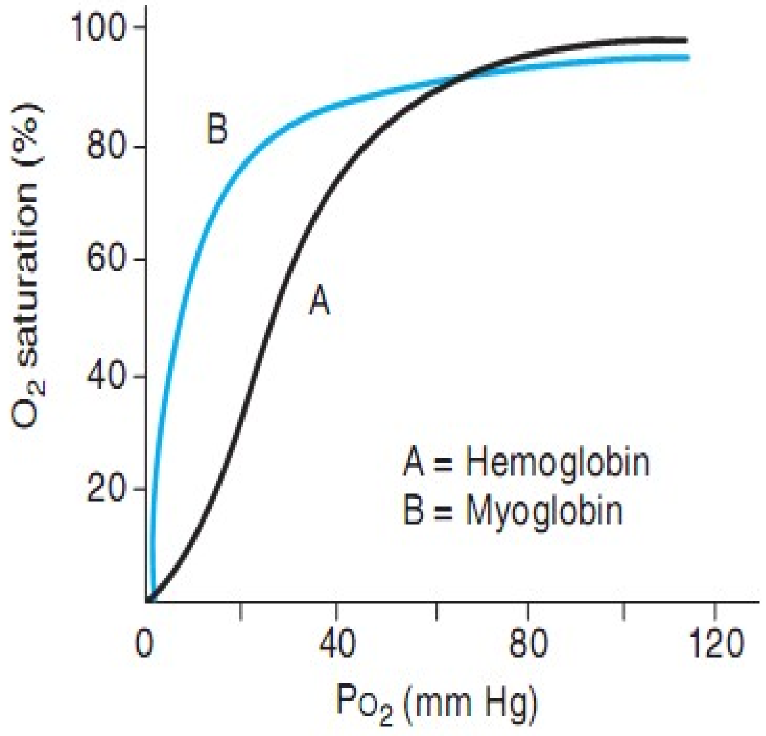
Oxygen - Myoglobin Curve

- It is **rectangular** in shape

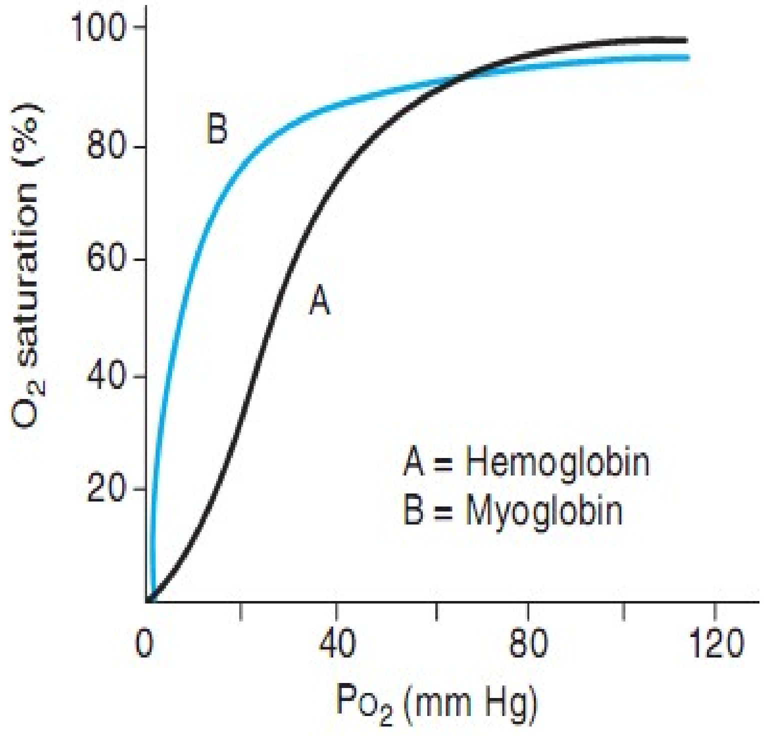
- It is to the **left** when compared with hemoglobin, So it shows a **higher affinity** for O_2, and thus promotes a favorable transfer of O_2 from hemoglobin in the blood.



Ganong, 2016

OXYGEN - MVOGLOBIN CURVE

- The steepness of the myoglobin curve also shows that O_2 is released only at **low PO_2** values. Thus, it acts as a **store** of O_2 to be available in **anaerobic conditions**.



Ganong, 2016

Lecture Quiz

1-Oxygen-dissociation curve is shifted to the left by which of the following:

A. Increased CO_2 tension.
B. Increased pH (alkalosis).
C. Increased blood temperature.
D. Muscular exercise.
E. Increase 2,3 DPG

Lecture Quiz

2-The shift of O_2- Hb dissociation curve to the right is associated with:

A. Increased affinity of Hb for O_2.
B. Decreased ability to deliver O_2.
C. Increased P50.
D. Increased O_2 carrying capacity of Hb.
E. Increase in O2 content of the blood.

SUGGESTED TEXTBOOKS

1. Guyton and Hall textbook of medical physiology, thirteenth edition 2016, Elsevier, chapter 41 , from page 532 to 534

2. Ganong’s Review of Medical Physiology, twenty-fifth edition 2016, McGraw-Hill Education, chapter 35, from page 640 to 642

3. Lauralee Sherwood Human Physiology: From Cells to Systems, Ninth edition 2016. CENGAGE, chapter 13, from page 472 to 475

Thank You